Material and Energy Recovery from Landfill Waste

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ISWA Working Group Energy Recovery
Vienna

NIPPON STEEL & SUMIKIN ENGINEERING CO., LTD
Nobuhiro Tanigaki
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1. Background and Purpose

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   ✓ Landfill waste analysis
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   ✓ Leaching tests

4. Commercial Application
   ✓ Waste Composition
   ✓ Effects of Landfill waste co-gasification

5. Summary
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5. Summary
Background and Purpose

- Bottom ash is classified as a “Waste” and difficult to be recycled in Japan.
- The capacity of landfill site is limited (short lifetime)

- Extending the lifetime of existing final landfill site
- Recovering material from landfill site (Urban mining)

Application of the Direct Melting System (DMS) for landfill waste processing and recycling materials from landfill waste via following steps.

STEP 1: Operation Test in Pilot Plant (20 t/d)

STEP 2: Application to Commercial Plant
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5. Summary
Gasifier - Co-gasification -

- **Waste Flexibility**
  - No Pretreatment (Max. 800 mm)
  - Co-gasification

- **High Syngas NCV**
  - Continuous syngas measuring
  - Approx. 5.9 MJ/m$^3$ based on 9.1 MJ/kg-waste
  - Refer to N.Tanigaki et. al. Waste Management

- **High Temperature & Reducing Atmosphere**
  - Toxic heavy metals are volatilized and distributed to fly ash.
  - Few toxic heavy metals remain in slag and metal.
  - **Recycling material**
  - **Landfill minimization**

Sewage sludge  | Bottom ash  | Landfill Waste  | Clinical Waste
---|---|---|---

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NIPPON STEEL & SUMIKIN ENGINEERING CO., LTD.
Waste Flexibility

- Landfill Waste
- Automobile Shredder Residue
- Incineration Residue
- Asbestos
- Sludge
- MSW
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5. Summary
Pilot Plant (20 t/day)
# Landfill Waste and MSW Compositions

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>LW</th>
<th>MSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>moisture content</td>
<td>%</td>
<td>24</td>
<td>30</td>
</tr>
<tr>
<td>combustible content</td>
<td>%</td>
<td>20</td>
<td>56</td>
</tr>
<tr>
<td>ash content</td>
<td>%</td>
<td>56</td>
<td>14</td>
</tr>
<tr>
<td>fine matter</td>
<td>%</td>
<td>48.3</td>
<td>2.6</td>
</tr>
<tr>
<td>dioxins</td>
<td>ng-TEQ/g</td>
<td>1.1</td>
<td>-</td>
</tr>
<tr>
<td>specific gravity</td>
<td>t/m³</td>
<td>0.68</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Bottom ash, sand and other fine grained-impurities and combustibles are included.
## Operation results

<table>
<thead>
<tr>
<th>Inorganic analysis</th>
<th>Unit</th>
<th>slag</th>
<th>Fly Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MSW only</td>
<td>MSW with LW</td>
</tr>
<tr>
<td>Si</td>
<td>%-dry</td>
<td>17.93</td>
<td>14.62</td>
</tr>
<tr>
<td>Ca</td>
<td>%-dry</td>
<td>25.09</td>
<td>18.82</td>
</tr>
<tr>
<td>Zn</td>
<td>%-dry</td>
<td>31</td>
<td>40.2</td>
</tr>
<tr>
<td>Hg</td>
<td>mg/kg</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cd</td>
<td>mg/kg</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Cr(^{6+})</td>
<td>mg/kg</td>
<td>&lt;2.0</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Pb</td>
<td>%-dry</td>
<td>11.7</td>
<td>20</td>
</tr>
<tr>
<td>As</td>
<td>mg/kg</td>
<td>&lt;0.5</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Se</td>
<td>mg/kg</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
</tbody>
</table>
Lead Distribution

- Due to high lead (Pb) concentration in the landfill waste to be processed, the lead concentration in fly ash is higher than in the case of MSW processing.

- The heavy metal distribution tendency is the same in the both cases.

Slag and metal quality are not varied when the landfill waste is processed with MSW.

The landfill waste co-gasification is one of the possibilities to recover materials from landfill waste.
# Emissions

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>MSW only</th>
<th>MSW with LW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>g/m³N</td>
<td>0.006</td>
<td>0.004</td>
</tr>
<tr>
<td>Sulfer oxide</td>
<td>ppm</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Hydrogen chloride</td>
<td>ppm</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nitrogen oxide</td>
<td>ppm</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Cabon Monoxide</td>
<td>ppm</td>
<td>5.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Dioxins (include co-PCB)</td>
<td>ng-TEQ/m³N</td>
<td>0.023</td>
<td>0.009</td>
</tr>
</tbody>
</table>

Both the conditions achieved lower environmental emissions from gasification and melting process.
# Slag Leaching Test

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>MSW only</th>
<th>MSW with LW</th>
<th>standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg</td>
<td>mg/L</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Cd</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Cr&lt;sup&gt;6+&lt;/sup&gt;</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/L</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>As</td>
<td>mg/L</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Se</td>
<td>mg/L</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

*1: Environmental Agency of Japan notification No.46

Values obtained satisfied environmental standards under both conditions
Fly Ash Leaching Test

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>MSW only</th>
<th>MSW with LW</th>
<th>standard value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg</td>
<td>mg/L</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Cd</td>
<td>mg/L</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Cr$^{6+}$</td>
<td>mg/L</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/L</td>
<td>0.005</td>
<td>0.006</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>As</td>
<td>mg/L</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Se</td>
<td>mg/L</td>
<td>&lt;0.002</td>
<td>0.008</td>
<td>&lt;0.3</td>
</tr>
</tbody>
</table>

*1: Environmental Agency of Japan notification No.13

LW could be processed by DMS without any additional facilities and changes of the operational conditions compare with those in case of the normal MSW processing.
The effectiveness of volume reduction at landfill site

To add 10% RW into MSW to be processed is effective to extend the lifetime of the existing landfill site.
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5. Summary
Niigata city has implemented the DMS to replace the conventional incinerator, aiming to extend the lifetime of the existing landfill site.

It has been in operation since 2002.

The final landfill site has a capacity of 98,000m³. 80,000m³ has been filled.
The process flow of old Facilities

- **Combustibles**
  - **Incinerators (120 t/16h)**
    - **Bottom ash**
    - **Fly ash**
  - **Final Landfill Site**

- **Sludge**

- **Incombustibles, Bulky waste**

- **Plastics**
  - **Volume Reduction and Solidification**
The process flow of new Facilities

- Combustibles
- Sludge
- Incombustibles, Bulky waste
- Plastics
- Recyclable waste

1. Point 1: No waste landfilled directly
2. Point 2: reducing the waste transferred to the landfill
3. Point 3: securing space for the fly ash

DMS (120 t/day)

Recycling Center

Recycling

Slag, Metal

Fly ash

Landfill Waste

Final Landfill Site

Reuse

glass, can, Plastic bottles
Excavation system

- Excavation
- Loading
- Sieving and conveying
- Landfilling
Overview of Landfill Site

Overview

Covered rubber sheets
Excavation and Transportation of Landfill Waste

Excavation

Transportation
Landfill Waste

Oversized Landfill waste

< 200 mm waste
## Landfill Waste Compositions

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Point A, Depth 3 m</th>
<th>Point A, Depth 3 m</th>
<th>Point C, Depth 3 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>moisture content</td>
<td>%</td>
<td>22</td>
<td>20.4</td>
<td>21.5</td>
</tr>
<tr>
<td>combustible content</td>
<td>%</td>
<td>40.7</td>
<td>10.6</td>
<td>22.4</td>
</tr>
<tr>
<td>ash content</td>
<td>%</td>
<td>37.3</td>
<td>68.9</td>
<td>56.1</td>
</tr>
<tr>
<td>Lower calorific value</td>
<td>MJ/kg</td>
<td>13.9</td>
<td>1.1</td>
<td>4.7</td>
</tr>
<tr>
<td>specific gravity</td>
<td>t/m³</td>
<td>0.64</td>
<td>1.27</td>
<td>0.92</td>
</tr>
</tbody>
</table>

High waste flexibility is required for processing landfill waste
## Environmental Circumstances

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Landfill site (outdoors)</th>
<th>Sieving area (indoor)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No work</td>
<td>Excavating work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Downwind</td>
<td>Upwind</td>
</tr>
<tr>
<td>Methane</td>
<td>ppm</td>
<td>2.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Dust</td>
<td>g/m$^3$N</td>
<td>0.013</td>
<td>0.012</td>
</tr>
<tr>
<td>Dioxins (include co-PCB)</td>
<td>ng-TEQ/m$^3$N</td>
<td>0.29</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Effect of Landfill Waste Co-gasification

**MSW Only**

- **MSW** 781 kg, 4.1 m³
  - Fly ash 17.5 kg
    - Slag 92.4 kg, 0.073 m³
    - Metal 22.6 kg, 0.010 m³
  - Chemical reagent
    - Detoxified ash 22.8 kg, 0.020 m³
  - Volume reduction 1/205

**MSW with LW**

- **MSW** 674 kg, 3.5 m³
  - LW 79 kg, 0.079 m³
  - Fly ash 19.0 kg
    - Slag 139.7 kg, 0.138 m³
    - Metal 39.9 kg, 0.018 m³
  - Chemical reagent
    - Detoxified ash 24.7 kg, 0.021 m³
  - Volume reduction 1/170
Effects of Landfill Waste Co-gasification

The lifetime of the existing landfill site can be extended for about 40 years.
Conclusions

✓ Landfill waste was processed by the Direct Melting System without any additional facilities and any changes of the operational conditions compared with those in case of the normal Municipal solid waste processing.

✓ 10% mixture of landfill waste with municipal solid waste is sufficient to extend the lifetime of the existing landfill site.

✓ Heavy metal distribution is the same tendency in the both case (with and without landfill waste).

✓ This Scheme (Co-gasification of landfill waste for minimizing landfill and recover material) was also applied to Commercial plant in Japan.

✓ As a consequence, the lifetime of the existing landfill site can be extended for about 40 years.
Thank you very much for your attention

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